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PRELIMINARY DESIGN OF A PORTABLE PROGRAMMABLE DATA RECORDER.(U)

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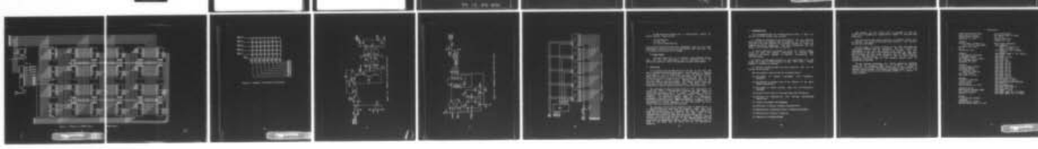

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A preliminary paper design of a portable data recorder has been completed and its projected performance analyzed. The recorder is a hand-held, battery-powered device that can record on a single tape cassette both analog (voice) and digital (keyboard) data. In addition, it provides visual and audible prompts for the operator as well as data playback and editing capabilities. Recorded digital data can be directly electronically entered into a computer data base. (over)

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Since the device is controlled by a microprocessor, it is very versatile in nature and, through simple programming (software) changes, can be adapted for use in a great variety of data-gathering applications. A preliminary design of the major components of the device, which include a microprocessor, keyboard, memory, tape-cassette drive, alphanumeric display, and power supply, is discussed. Projected production costs for the device range from $600 to $1000.

CONTENTS

Page

FIGURES

1. INTRODUCTION

As oil and gas exploration and recovery operations move farther from shore into more hostile environments on the Outer Continental Shelf, the U.S. Geological Survey (USGS) has found it necessary to collect from lease operators more and more data concerning the installation, operation, and maintenance of safety and pollution control equipment. In addition, each installation is inspected by USGS personnel about twice a year. Equipment operating performance is again recorded at this time.

Similar types of inspection procedures are carried out daily in many industrial processing and manufacturing facilites. In these situations, inspection procedures extend from machine-performance checks to quality-control checks of the manufactured item.

For the mass of data resulting from these inspections to be of maximum use, it must be entered into a computer-controlled data bank. There it may easily be stored, analyzed, and categorized, and provide both raw and statistical data that will aid in the recognition of such things as potential safety problems related to safety component malfunction. This information can lead to decisions concerning required research and development, better equipment specifications, identification of components that have marginal performance, and more realistic component inspection and maintenance scheduling.

While it can be seen that such a program can lead to beneficial results, it is also evident that the implementation of this program can lead to a greater paperwork load for both government and industry. This would result if the traditional recording method were followed: manually filling out forms with the appropriate data and written comments, recoding these data into the appropriate format for keypunching, and subsequently keypunching these data for input to a computer data bank. In addition, as shown in figure 1, this method allows human error to enter at three points in the data-collection process: (1) in filling out the form, (2) in recoding the data, and (3) in keypunching the data. Also, written comments might tend to be omitted or incomplete because of the inspecting personnel's dislike of writing or paperwork in general.

(This attitude was expressed many times by the industry personnel encountered during recent visits to offshore oil installations. Since that time, a requirement for significantly increasing that paperwork load has been advanced by USGS.)

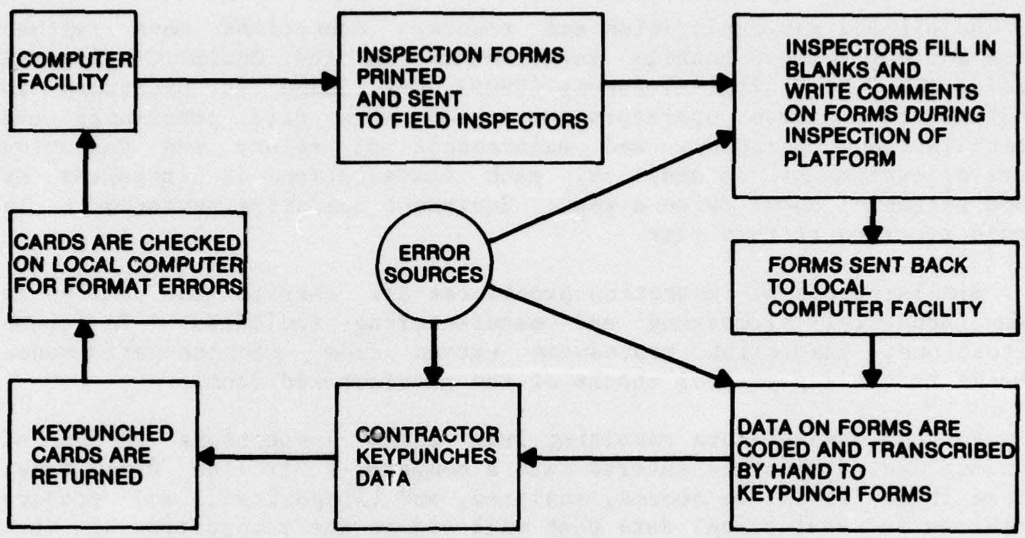

Figure 1. Data-handling system currently used by USGS.

An apparatus to significantly decrease the paperwork load associated with inspection activities is explained here. Essentially, it is an electronic recording device with which inspectors would record (either digitally, via keyboard entry, or verbally) all the pertinent data and comments concerning their inspections. These data could then be played back for entry into the computer data bank. The digital data would be directly entered electronically; verbal comments could be played back to a typist who would then enter these data in the traditional manner. When used with the current USGS collection, storage, and retrieval system for offshore platform inspection data (as shown in fig. 1), this device could significantly simplify this procedure (see fig. 2).

To reduce error sources in the data-collection process, this device could visually and verbally prompt the operator, check the format of the digital data for errors, and eliminate the need for keypunching the digital data. Also, such a device would greatly ease the burden on the operator or USGS inspectors who must provide the operational data required both now and in the future.

Figure 3 is a block diagram of the proposed portable data recorder (PDR). It would have the following general characteristics: (1) portability, (2) battery power, and (3) low power consumption.

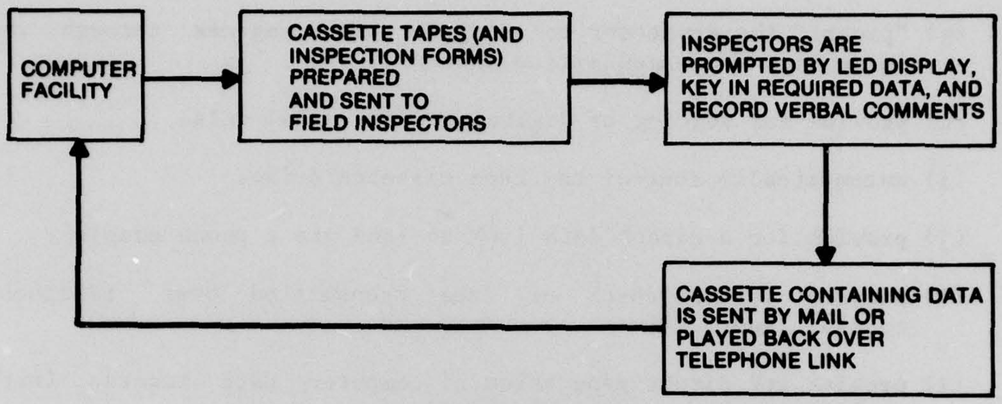

Figure 2. Proposed data-handling system using portable data recorder.

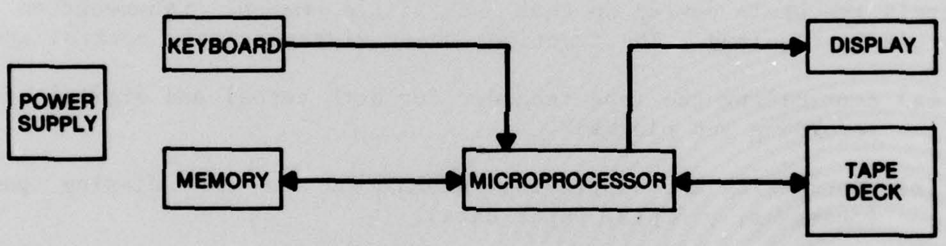

Figure 3. Block diagram of portable data recorder.

The apparatus would

(a) provide for manual keyboard entry of coded data,

(b) display these digital data as they are entered,

(c) provide for error checking of digital data format,

(d) provide for verbal input of comments,

(e) provide for playback and redisplay of digital data,

(f) provide for audio playback of verbal comments,

(g) "prompt" the inspector to aid in his progress through the inspection data-acquisition process,

(h) provide for editing of digital and/or verbal data,

(i) automatically control the tape cassette drive,

(j) provide for a direct data link to land via a phone coupler,

(k) provide for a check of data transmitted over telephone coupler, and

(l) provide for direct generation of computer data records (with verbal comments typed in by hand).

An optional feature, if desired, would be built-in calculator capability.

The microprocessor, whose major components are shown in figure 3, controls the whole device so that as little manual intervention as possible is required. The functions under microprocessor control are

(a) controlling the tape recorder for both verbal and digital data recording and playback,

(b) controlling and displaying information on the display panel (messages, prompts, input data),

(c) inputting data from the keyboard and checking their format and limits,

(d) controlling serial output to a modem or teletype terminal, and

(e) optionally performing calculator functions.

2. FUNCTIONAL DESCRIPTION

The basic controlling program will be stored in a nonvolatile read-only memory (ROM). Input data are buffered in volatile random-access memory (RAM) for verification and editing, and then written onto tape. The tape itself will contain both the digital and voice data that have been entered, as well as any initial verbal messages for the operator, and unique data for the program.

Typical operation of the system allows the input of descriptive digital information from a prerecorded tape via the tape deck to be stored in memory. This information is used to program the PDR for a

particular type of operation. (If the PDR is to be used for one application only, this information can be permanently stored in nonvolatile memory.) Operating in accordance with this information, specific directions for the operator are output to the alphanumeric display. In addition, verbal instructions may be prerecorded on tape to provide a second type of operator instruction.

Digital data are entered via the keyboard and are stored in RAM while data are gathered. These data may be updated or edited before being recorded onto the tape. Verbal comments are stored directly on tape.

3. SYSTEM DESIGN

So that the PDR can be as flexible and inexpensive as possible, the design is based upon the use of a microprocessor. This type of design lends itself to many diverse applications, where changes in software only would be required to implement specific capabilities within the existing hardware design. As shown in figure 3, the major components of the PDR include

(a) microprocessor,
(b) memory,
(c) keyboard,
(d) tape deck,
(e) alphanumeric display, and
(f) power supply.

3.1 Microprocessor

The PDR uses an RCA 1802 COSMAC microprocessor. This 8-bit complementary metal-oxide semiconductor (CMOS) integrated circuit (see fig. 4) was chosen because of the low power consumption and high noise immunity of CMOS devices and because of its convenient word size bit (8 bits). The microprocessor communicates with other devices through an 8-bit bidirectional data bus and 15 input/output control lines. Memory addressing is through a multiplexed 8-bit address bus allowing 16-bit addressing. Other features of COSMAC include direct sensing of four lines, direct control of a single line, interrupt, and direct memory access (DMA) capability.

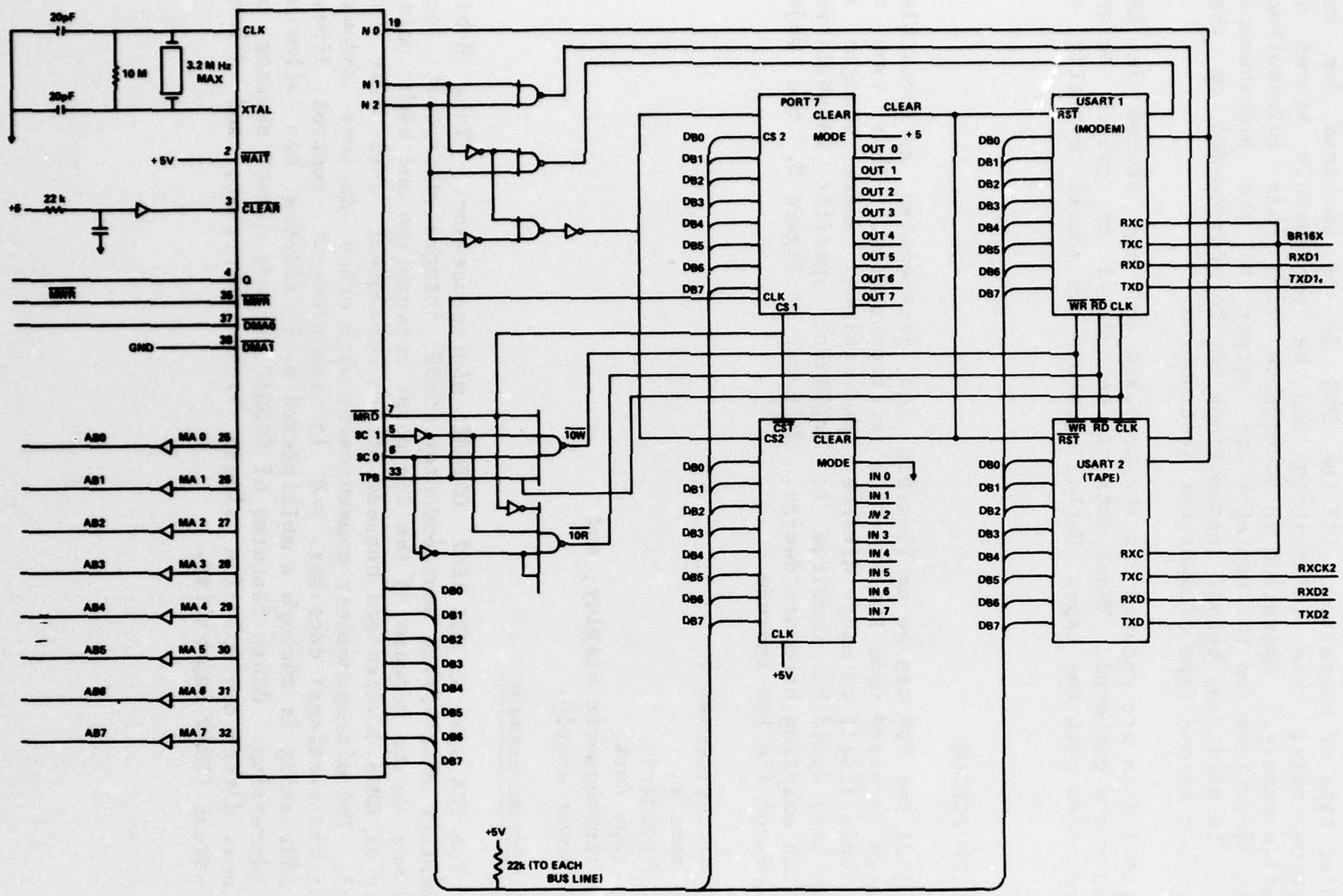

Figure 4. Schematic of COSMAC microprocessor system.

3.2 Memory

The PDR contains 2048 bytes of ROM and 2048 bytes of (read/write) RAM. The system (see fig. 5, p 13) is designed to allow the use of either the RCA CDP1832 mask programmable ROM or the industry-type 2704/8704 electrically reprogrammable ROM. RAM comprises an RCA CDP1822 256 × 4 bit static memory. If needed, memory expansion is straightforward.

3.3 Keyboard

The system uses a 5 × 8 matrix keyboard with momentary switch closures. To determine if a switch has been depressed, the microprocessor program scans the keyboard. This is accomplished by setting one of the five output bits to the keyboard low (see keyboard schematic in fig. 6, p 15) and then reading in the state of the eight keyboard input lines. If a switch is depressed, the low output line is connected to one of the input lines, and the input line is pulled low. By sequencing through each of the five output lines one at a time, a depressed key can be sensed and decoded.

3.4 Tape Deck

The tape deck in the system (see fig. 7, p 16) can record and play back both analog (voice) and digital information. This is implemented by using a Triple I cassette deck which records two tracks of information on a standard Phillips-type audio cassette. One track would contain audio information and the other digital. The digital system would store data on the tape using two different frequencies to represent the two binary states. The technique used[1] was selected because of its self-clocking and therefore tape-speed-tolerance feature. The data are stored in a bit serial fashion in records of arbitrary but known length. The voice-recording capability dictates the use of at least one track of analog recording; cost then dictates that the other track be analog as well.

3.5 Alphanumeric Display

The original system design called for Hewlett-Packard HDSD-2000 alphanumeric light-emitting diodes (LED's) for the display elements. Since the original design, Litton has come out with a display element which is cheaper and easier to use, the Litronix DL-1416. This integrated circuit is treated as memory and, therefore each character is written into the appropriate space using its standard ASCII (American Standard Code for Information Interchange) code (see fig. 8, p 18). This is a big improvement over the HP chip since much of the complicated interface circuitry is eliminated.

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[1]*Don Lancaster, Build the Bit Boffer, Byte Magazine (March 1976).*

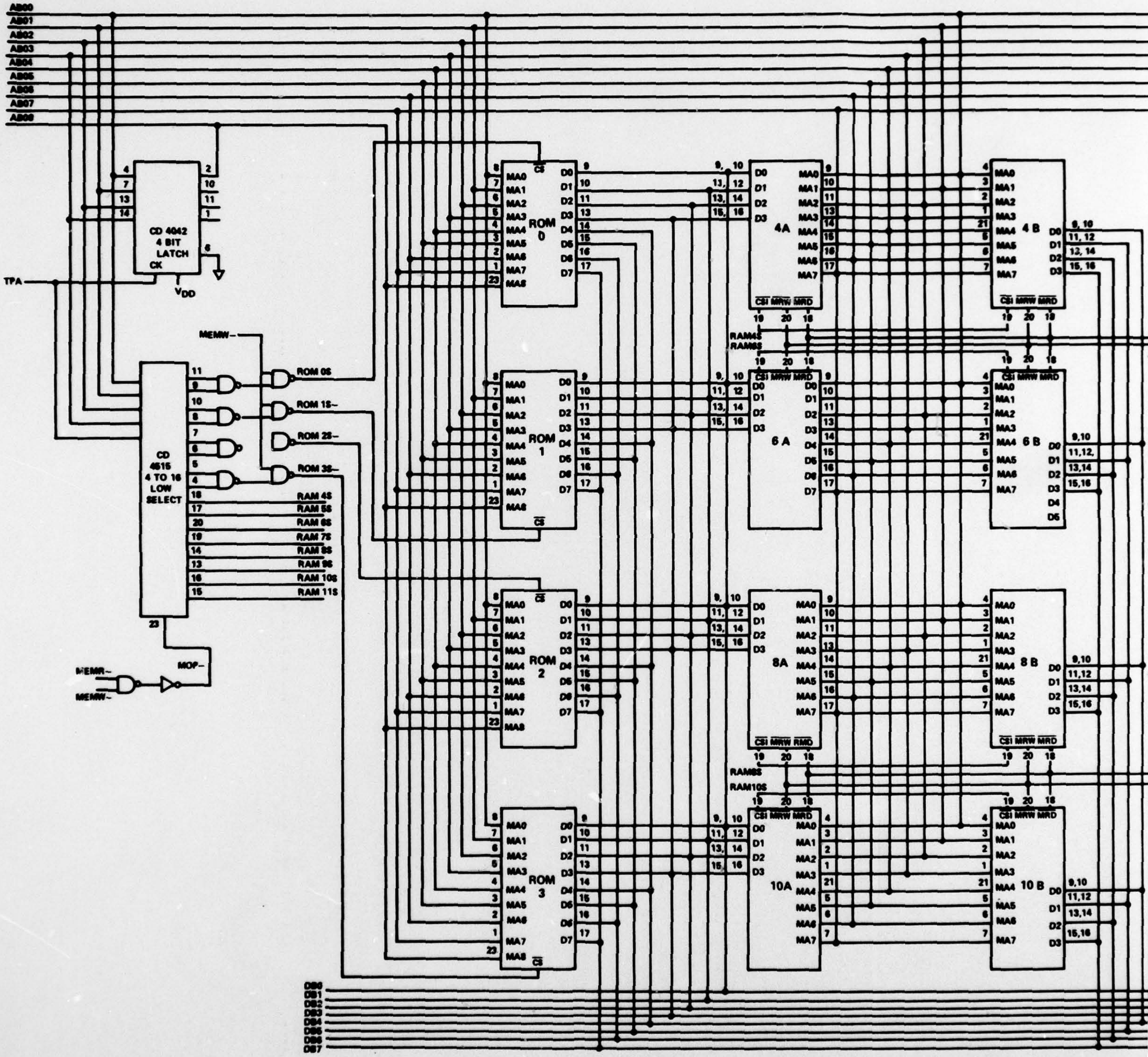
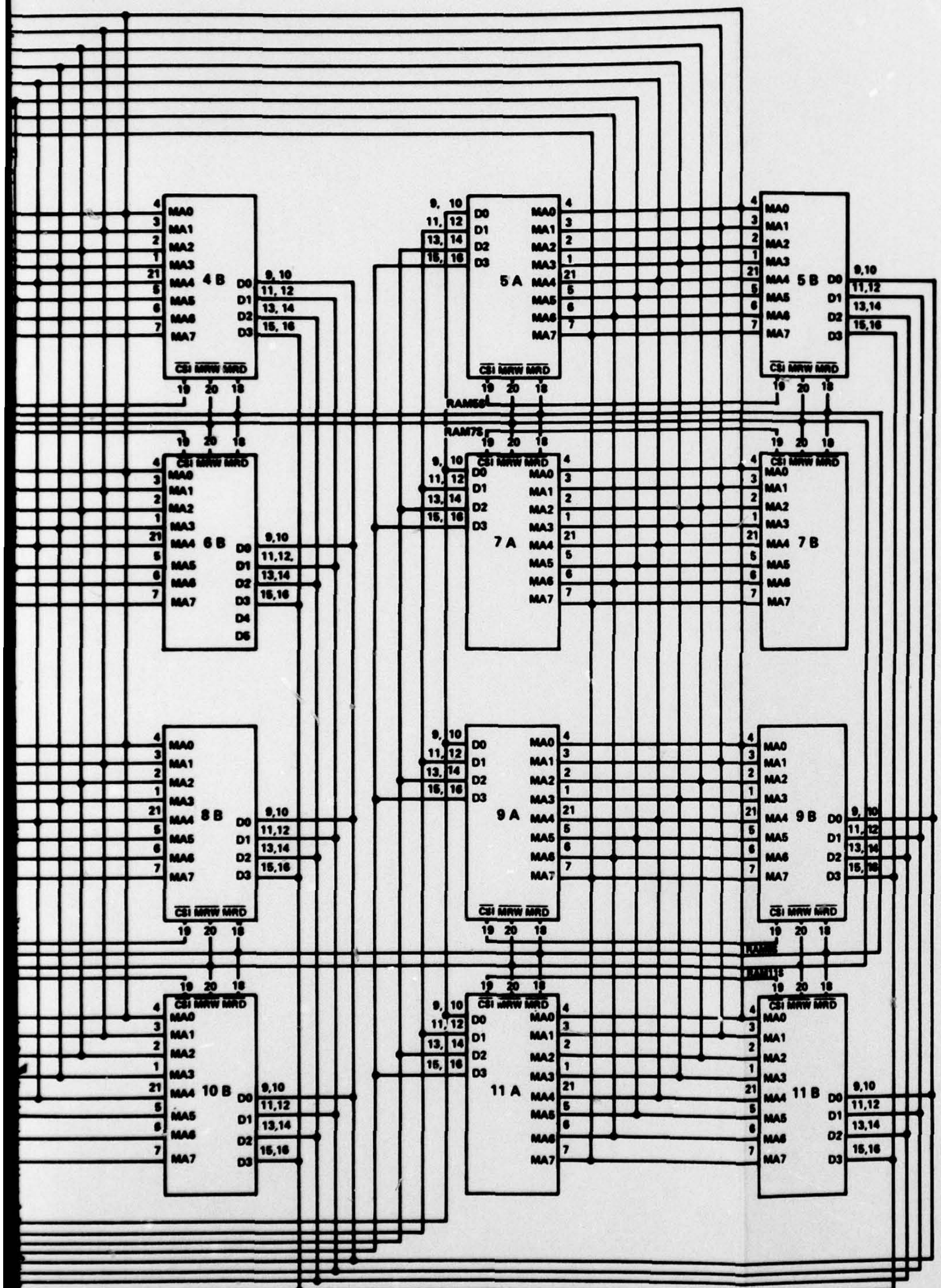


Figure 5. Schematic of COSMAC memory.



COSMAC memory.

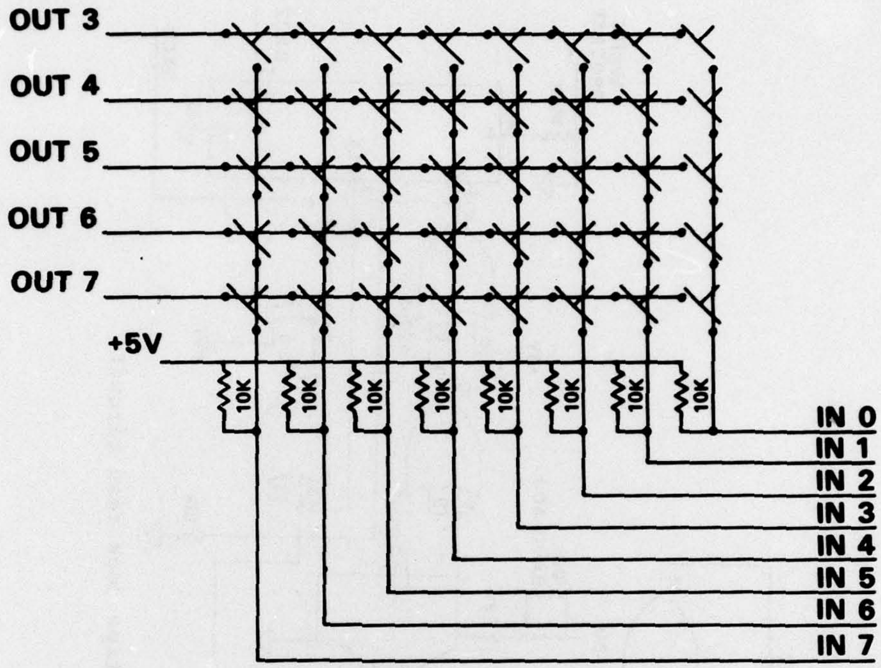


Figure 6. Schematic of keyboard and interface.

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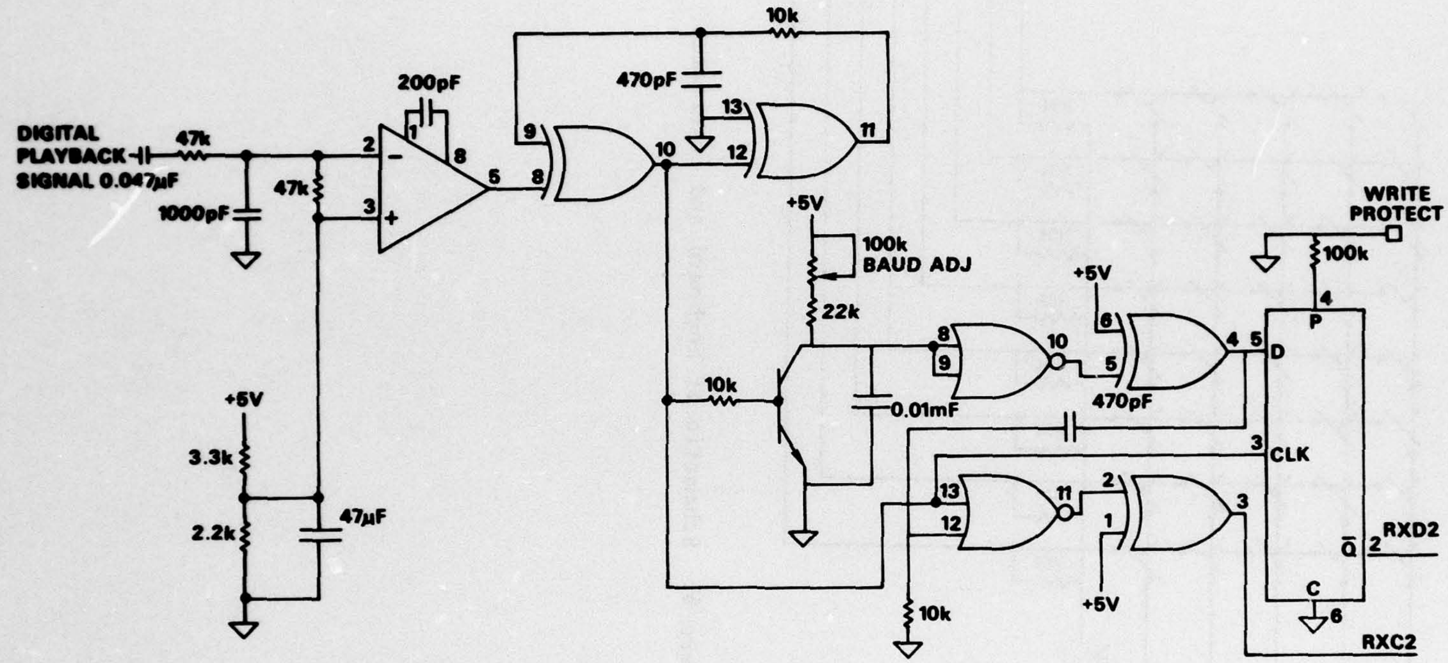

Figure 7(a). Schematic of tape deck read circuit.

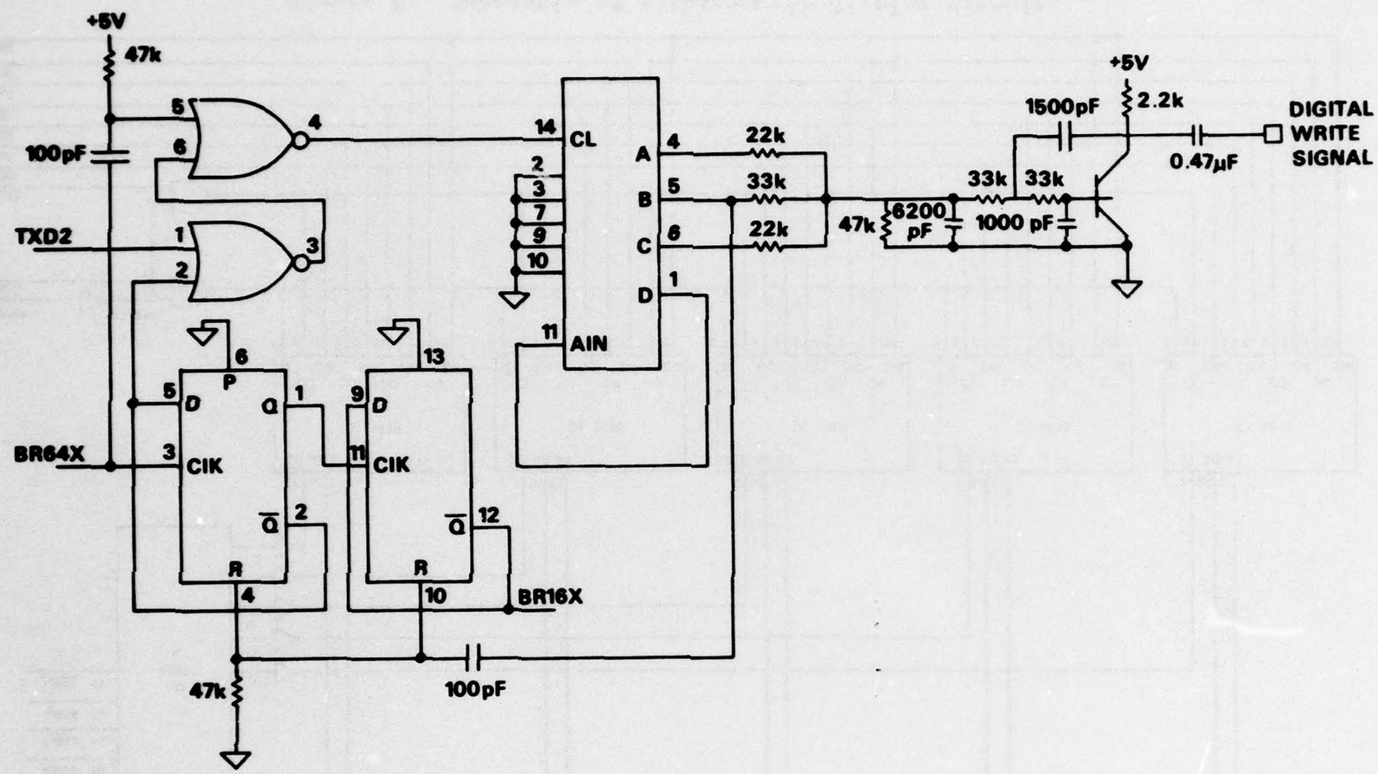

Figure 7(b). Schematic of tape deck write circuit.

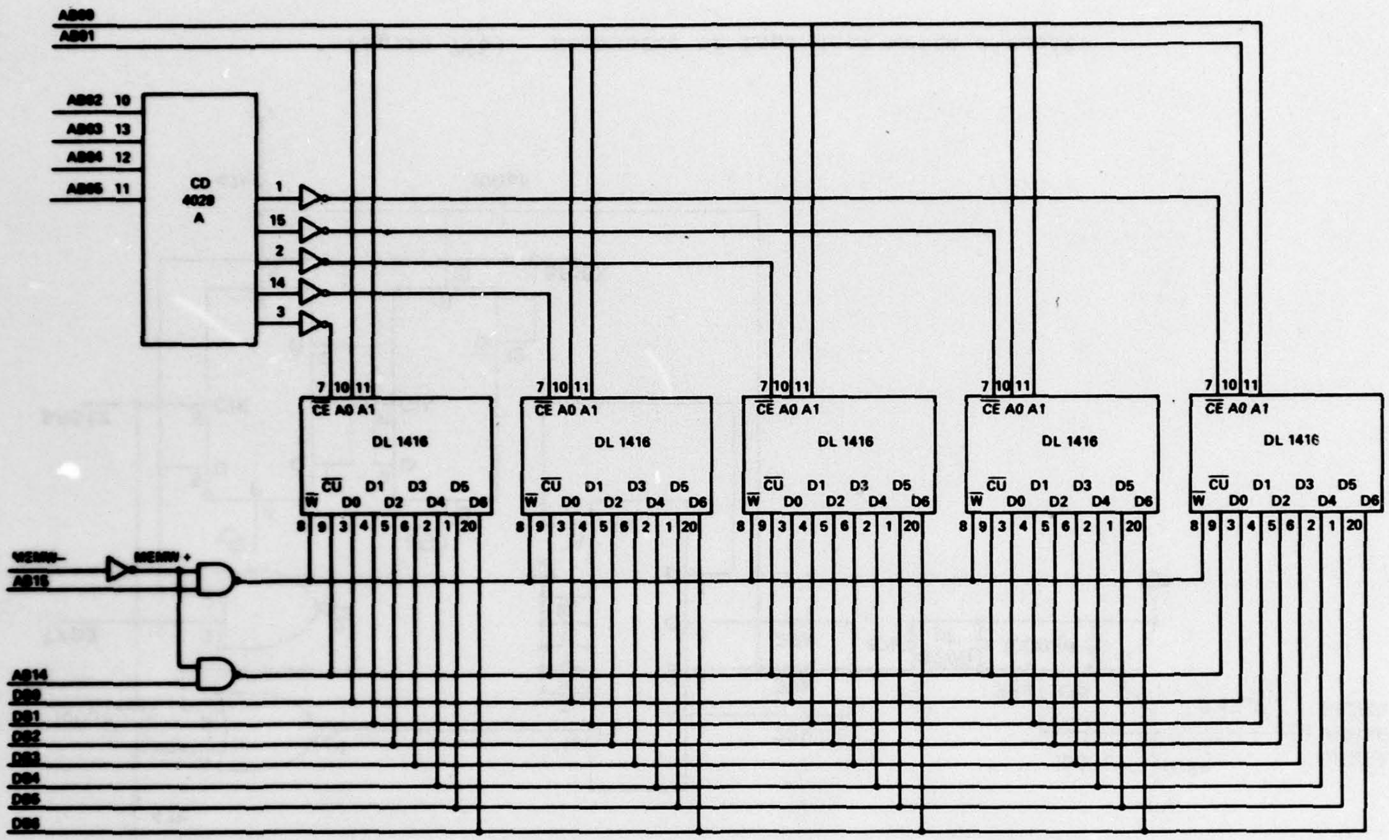

Figure 8. Schematic of alphanumeric display circuit.

An LED display was chosen over a liquid-crystal display for several reasons. These include

(a) availability,
(b) cost, and
(c) circuit simplification.

Liquid-crystal displays do have some advantages, such as low power requirements and good visibility in high ambient light conditions, and if necessary, the display can be changed.

3.6 Power Supply

The power supply will be a standard nickel-cadmium battery pack. The size and manufacturer will be determined after the laboratory prototype is built and analyzed for power requirements.

4. CONCLUSIONS

It is expected that the PDR device will be worn on the belt and have a removable keyboard-display module. The belt module is expected to be about 15 × 15 × 10 cm and weigh 1 to 3 kg. The keyboard display module should be about 15 × 10 × 2.5 cm and weigh less than 0.1 kg. If the unit is built in quantities of 500, the expected cost will be less than $1000 at current prices. Expected price drops in key circuitry elements such as the memory and display should bring the price down to less than $750 in about a year. The above total cost estimates are based on adding 30 percent to the actual parts cost.

The advantages of using a microprocessor in this application are significant. First, a microprocessor provides the high degree of control described above, yet it is compact, lightweight, relatively inexpensive, and requires little power to operate. Second, it is versatile. Its nonvolatile memory (ROM) can be individually programmed to make the overall apparatus adaptable to many different data-acquisition applications. ROM's with different programs can be interchanged in a single apparatus so that one device can serve several different data-acquisition functions.

The advantage of this overall approach is that it makes the use of a computer-controlled data base for manually input data both convenient and practical. It eliminates the need for hand-written forms and the key-punching that must go with them. This in turn eliminates much repetitive labor with the errors that go with it. In addition, the overall time from when the data are originally acquired to when they are available as part of the computer-controlled data base should be significantly reduced. Finally, an estimated cost of $1000 or less means that the device will not be prohibitively expensive.

5. RECOMMENDATIONS

It is recommended that the following steps be taken to prove out and then build the portable data recorder.

I. Witness an inspection in the field both to see the operation first hand and to get comments from the inspector. It would also be desirable to have the inspector use a cassette recorder to record his comments during this inspection. This would demonstrate how that aspect of the recorder would work in practice.

II. Build a laboratory prototype to prove out circuit design. Design and debug the software. Demonstrate to selected USGS inspectors and obtain comments for possible incorporation into prototype design.

III. Build a field-rugged prototype to show approximate size and weight and to show its effectiveness in actual field trials. Modify hardware or software as required.

IV. Develop a drawing package from which production data for the product can be derived.

The above general steps include the following efforts.

(a) procurement of software development tools (assembler, simulator)

(b) installation of software tools on the computer at the Harry Diamond Laboratories

(c) procurement of system hardware (tape deck, microprocessor, displays)

(d) printed-circuit board or wire-wrap layout and fabrication

(e) provision for compatibility with existing data-handling capabilities

(f) software development and debugging

(g) definition of operator interface characteristics

(h) demonstration of prototype device to inspection personnel

(i) modification of design, if required

(j) completion of drawing package.

The software for this effort will be designed to show the feasibility of automating a representative sample of data-recording needs only.

Once field trails have proven successful, a follow-up effort will be required. This effort will include tasks related to both hardware and software development.

The development of software to handle all the USGS data-gathering requirements offshore must be undertaken. This will include the programming of not only the portable data recorder, but also modification of that part of the program now used with the USGS data base to produce the data forms currently used by USGS inspectors offshore. This modification is needed so that the tape cassette containing instruction data for the portable recorder could be automatically generated.

Further, hardware development will include mechanical packaging design for the production model of the recorder. In addition, verfication of the production model design must be done through an adequate testing program. The hardware development phase of this work could be handled as part of the procurement package of a quantity of these recorders.

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